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ORIGINAL PAPER

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Four-year monitoring of parasite communities in gobiid fishes of the south-western Baltic

I. Guild and component community

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Abstract The parasite communities of goby species (Teleostei, Percomorphi) from the south-western Baltic Sea were investigated from 1997 to 2000 in three different seasons. In total, 30 parasite species were found in the guild of four goby spp. from Dahmeshöved (Lübeck Bight). The component community of *Pomatoschistus minutus* comprised 22, *Pomatoschistus pictus* 20, *Gobiusculus flavescens* 18 and *Gobius niger* 14 parasite species, whereas *Pomatoschistus microps* from the Salzhaff (Mecklenburg Bight) harboured 24 species. The digenean *Podocotyle atomon* (ingested with prey) and *Cryptocotyle concavum* (active penetration) were the most common parasites. *Cryptocotyle lingua* and the nematode *Hysterothylacium* sp. in *Gobius niger* as well as the specialists *Aphalloides timmi* and *Apatemon gracilis* (Digenea) in *Pomatoschistus microps* were also very abundant. There were large changes in the parasite communities within the years as well as between the seasons of a year; only *Gobius niger* presented rather homogeneous communities. The ratio of core parasite species in the hosts was at most 28% (*Gobiusculus flavescens*) and at least 9% (*Gobius niger*). The core species can attain their maximum values at different seasons, which is not only influenced by the parasite but also by the host species. It is concluded that the composition of parasite communities was predominantly determined by the ways of life of the host as well as of the parasite species. Another important factor is the population density of intermediate hosts.

Introduction

Investigations on parasite communities are useful for the knowledge they provide on community structure and dynamics (Esch et al. 1990) and for estimating environmental influences (Khan and Thulin 1991). The parasites of gobiid fishes from the brackish Baltic Sea have been studied with respect to their distribution and ecology since 1987 (see Zander and Reimer 2002). The aim of these studies was to determine the numbers of parasite species as well as their prevalence and intensity of infection in five goby host species. The results varied in different localities of the south-western Baltic Sea according to two main environmental factors: salinity (Kesting and Zander 2000) and eutrophication (Zander 2002). Albeit the parasite species spectrum of gobies is very similar, individual host species have developed several characteristic patterns in harbouring parasite specialists or defence against distinct parasites (Zander 2001). When the results from the Dahmeshöved (Lübeck Bight) were compared between 1987 and 1996 (Zander and Kesting 1996; Zander et al. 1993, 1999), certain differences also became obvious, particularly those caused by increased numbers of parasite species.

The gobies investigated are small marine fish which also live in brackish and sometimes even in fresh water. They are mostly found in shallow habitats where many parasites can also exist in intermediate and final hosts or as free larval stages. *Pomatoschistus microps* (common goby) lives directly at the shore whereas *Pomatoschistus minutus* (sand goby, on sand), *Pomatoschistus pictus* (painted goby) and *Gobius niger* (black goby, on hard bottoms) are found in 2 m and deeper. *Gobiusculus flavescens* (two spotted goby) swims a short distance above rocky bottoms or seagrass meadows. Only *Gobius niger* can live for 3 years; the other species die off after spawning in their second year. Thus, they are best suited for studies of colonisation by and seasonality of parasites (Zander and Kesting 1998). Because the characteristics of the goby hosts are very similar, they can be considered as a guild in the sense of Root (1967). Nevertheless, the parasite fauna of a single goby species is additionally influenced by its particular way of life, as described above.

The aim of the present study is to reveal the qualitative and quantitative changes of parasite species

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numbers and their prevalence over a period of 4 years. Zander et al. (1993) considered that investigations of 4 years may encompass an optimal number of parasites. The results can be compared with previous results from Dahmeshölved, Lübeck Bight, which were collected in 1987. In addition, seasonal fluctuations which are focussed especially on the role of core and satellite species in the parasite communities are also considered (Holmes and Price 1986). The realisation of niches is another important factor which may influence the composition of component and infra-communities and may answer the question as to which parasite species can exist together with other parasite species. This and the relationships between the size of hosts and the intensity of infection will be a second centre of interest.

Between 1997 and 2000, a new set of samples was collected in the Lübeck Bight and Salzhaff, Mecklenburg Bight, south-western Baltic Sea. They comprise, for the greatest part, seasonal catches of five goby species in every year. The results in terms of guild and component community are presented here in part I, whereas the peculiarities of the infra community are dealt with in part II.

Materials and methods

The areas of investigation lie on the German Baltic coast and comprise: (1) the upper littoral of the Lübeck Bight at the lighthouse of Dahmeshöved, and (2) the shallow beach of the Salzhaff in north-western Mecklenburg. Dahmeshöved was visited in spring, summer and autumn in the years 1997–2000. Here, the goby species *Pomatoschistus minutus, P. pictus, Gobiusculus flavescens* and *Gobius niger* were present. The Salzhaff was visited only in spring 1997–2000 in order to obtain specimens of *Pomatoschistus microps* which are very abundant there.

The fish were caught in the sublittoral of Dahmeshöved in a boulder and pebble ground of 3–6 m depth, about 200 m away from the beach, and on a 0.2–0.5 m deep sand bottom at the beach of the Salzhaff. The fish were caught in Dahmeshöved by means of SCUBA using a round hand net of 0.4 m diameter and 1 mm mesh size. They were caught at the Salzhaff by a hand net with the same diameter and mesh size but with an even, strengthened margin. The fish caught and investigated comprised 293 *Pomatoschistus minutus,* 201 *P. pictus,* 234 *Gobiusculus flavescens*, 71 *Gobius niger* and 162 *P. microps*. They were fixed in 10% kohrsolin.

The fish were inspected externally, including mouth and gill chamber, and were ventrally opened in order to the remove the liver, gonads and gut. The liver was squeezed between slides, the gonads teased apart with needles and the gut prepared by making a incision along its total length. Its contents were then removed and carefully checked for parasites. Finally, the body cavity and kidney were inspected. The parasites were determined mostly to the species level. This was facilitated by clearing in lactate acid.

The prevalence and (mean) intensity (as defined by Bush et al. 1997) were determined. The importance of the parasite-host relationship, expressed as the status as core or satellite species (Holmes and Price 1986), could be best described by the abundance calculated as prevalence×intensity. The scale comprises values >2 as core species, 0.6–2 as secondary species, 0.2–0.6 as satellite species, and <0.2 as rare species (Zander et al. 2000).

As statistical parameters, means ± SE were calculated and analysis of variance based on values of prevalence was carried out. The Sörensen index was used as an ecological parameter.

Results

Guild community

In total, 24 parasite species infected the common goby, *Pomatoschistus microps*, from the Salzhaff from 1997 to 2000 (Fig. 1). Approximately 22 and 20 parasite species were found in *P. pictus* and *P. minutus* from Dahmeshöved, respectively, whereas fewer parasites species were found in *Gobiusculus flavescens* and *Gobius niger* (18 and 14, respectively). When single years are considered, at most 18 and 15 (*P. microps*: 1999, 2000), 14 and 15 (*P. pictus*: 1998, 2000) or 13 parasite species (*P. minutus*: 1999) infected the hosts. In *Gobiusculus flavescens* and *Gobius niger* ten or less parasite species were found in 1999 and 2000 (Fig. 1). The whole goby

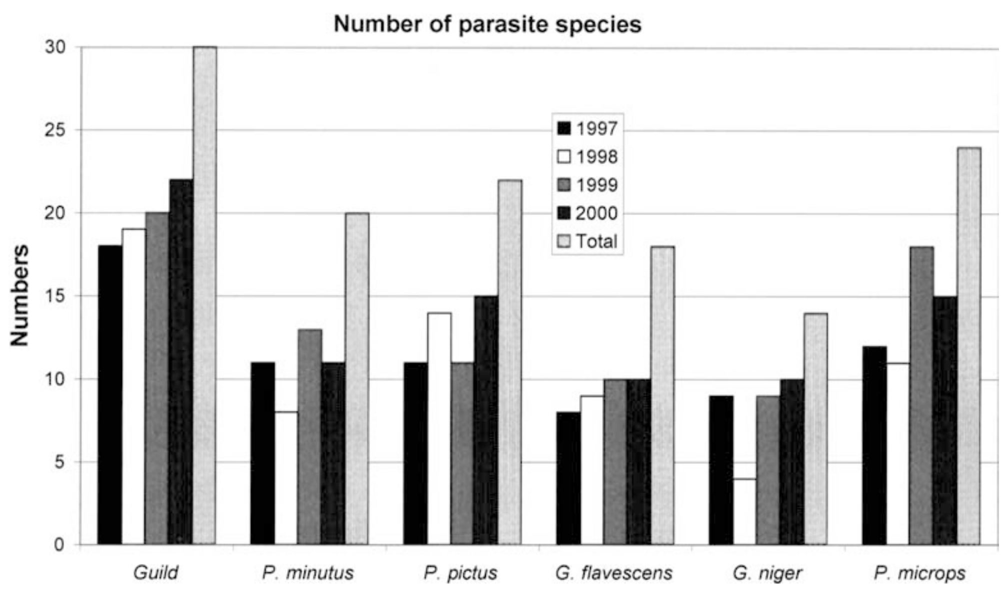

Fig. 1 The total number of parasite species from the goby guild and single goby species from Dahmeshöved for the years 1997–2000

guild of Dahmeshöved harboured 30 parasite species during the 1997–2000 sampling period (Zander 2002). In terms of single years, the guilds clearly surpass the numbers of single hosts.

Seasonal alterations in species numbers and prevalences

There were several differences between the goby hosts in terms of seasonal infection by parasites (Table 1). *Gobiusculus flavescens* showed a trend for the highest prevalence in spring and summer combined with the greatest numbers of parasite species in summer (Table 1). The same result was found in *P. minutus* which, however, had a maximum of parasite species in autumn (Table 1). Although the number of parasite species was very low in spring, all *P. pictus* were infected. This was also found in summer. The prevalences were still high in autumn when most parasite species were found (Table 1). The high prevalences in these three hosts were influenced by only a few parasites, such as *Cryptocotyle concavum* and *Podocotyle atomon*. In *Gobius niger*, *Cryptocotyle lingua* and *Hysterothylacium aduncum* were also important, although only values for autumn could be taken into account (Table 1). All *Pomatoschistus microps* from Salzhaff were infected in spring; the specialists *Aphalloides timmi* and *Apatemon gracilis* also have a great influence on these high prevalences. All common gobies harboured *C. concavum* in 1998–2000 as well as *Aphalloides timmi* in 1999 and 2000 (Table 1).

An analysis of variance, on the two most abundant parasites, *C. concavum* and *Podocotyle atomon*, only showed a significant difference in seasonal infection for both parasite species in *Pomatoschistus pictus* (Table 2). In *G. flavescens*, the variation in *Podocotyle atomon* was significant whereas in *Pomatoschistus minutus* this was not the case.

Species identity during seasons and 4 years

The parasite species were not identical between sampling months over the course of the 4 years (Table 3). The greatest alterations within the years occurred in *P. pictus*; *P. minutus*, with the Sörensen index value attaining more than 63% only in 1997, for *Gobiusculus flavescens* only in 1999. In contrast, *Gobius niger* was highly homogeneous within each year, attaining as much as 89% in 2000.

After comparing the respective seasons from 1997 to 2000, only *Gobius niger* and *P. microps* had values of greater accordance in terms of similarity (Table 3). This means, in most cases, a strong substitution of parasite species during the course of a year as well as over a longer time period. The component communities between the hosts from Dahmeshöved were inhomogeneous. Higher values were found in comparing *P. pictus*, rather lower ones in comparing *Gobius niger* and *Gobiusculus flavescens* with other species (Table 3). When *P. microps* from Salzhaff was included, only the identity with *P. minutus* and *P. pictus* was of greater accordance.

Parasite core and satellite species

The ratio of core species was below 30% in every host. It was highest in *P. pictus* and *Gobiusculus flavescens*, but even below 10% in *Gobius niger* (Fig. 2). Conversely, the ratio of satellite species was highest in *Gobius niger* (88%) which was followed by *P. minutus* (71%). The values of secondary species in no case surpass those of core species (Fig. 2).

Changes in abundance during the course of a year are listed in Fig. 3. *Podocotyle atomon* was a core species in *G. flavescens, Pomatoschistus minutus* and *P. pictus* in spring and summer, but a secondary or satellite species in autumn. This parasite was at most a secondary species in *P. microps* in spring and was lacking in *Gobius niger*. The situation with *C. concavum* is not as clear because it infects *P. pictus* strongly in autumn but less in spring and summer. *P. microps* was highly infected in every spring by *C. concavum*, while the status changed randomly in the other three species. The same is true for *C. lingua*. Other parasite species like *Asymphylodora demeli*, *Hysterothylacium* sp. or *Echinorhynchus gadi* attained at most the status of secondary species in spring and summer, respectively. High values are also found for infections with *Trichodina* sp. or *Gyrodactylus* sp. which, however, were present only in a few samples (Fig. 3). All other selected parasite species appeared irregularly and did not exceed satellite status.

Discussion

The most important result of this study is related to the species richness of parasites which was found during the 4 years in each species as well as in the whole goby guild. This comprised as many as 35 parasite species of which were 69% were found in *Pomatoschistus microps* and 63% in *P. pictus*. In contrast, *Gobius niger* harboured less than half (40%) of the species. This cannot only be due to the fewer black gobies sampled , because this restriction is not only valid for *Gobius niger* but also for *P. microps* which turned out to be the host with the richest parasite community. A more plausible explanation for this discrepancy is a lack of specialist parasites within the goby guild. As exceptions, *Aphalloides timmi* and *Apatemon gracilis* appear commonly in *P. microps*, but in the other gobies have a very low abundance or are not present at all (Zander 2001). In comparison with the whole period of the investigation, in a single year at most only 75% of the parasite species were found with the minimum being 55% in *G. flavescens*.

Some parasite species which were previously found in the same hosts (Zander et al. 1993, 1999; Zander and Kesting 1996) were now absent. These are *Corynosoma* sp.

Table 1 Prevalence of parasites from three seasons of the years 1997–2000 in five gobiid fishes as hosts. Brackets indicate a low sample size

Year	1997			1998			1999			2000		
Month	June	July	September	June	July	September	May	July	September	June	July	September
Pomatoschistus minutus												
Number of hosts	55	46	54	12	10	16	2	30	18	9	24	17
Gyrodactylus spp.		2.2						30.0		66.7		11.8
Cryptocotyle concavum	7.3	8.9	20.4	16.7	20.0	6.2	(50)	6.7	5.5	55.5	12.5	23.5
Cryptocotyle lingua		13.1	3.7					3.3				5.9
Tylodelphis podicipina									5.5			
Podocotyle atomon	74.5	95.6	1.8	100	70.0	43.7	(100)	80.0	16.7	88.9	50.0	11.8
Aphalloides timmi									5.5			
Acanthostomum balthicum												5.9
Asymphylodora demeli		10.0	7.4		30.0	25.0	(100)			11.1		
Derogenes varicus						6.2						
Lecithaster gibbosus		2.2										
Microphallid metacercariae			3.7									
Schistocephalus solidus						37.5	(50)		5.5			
Bothriocephalus sp.	7.3		11.1									
Hysterothylacium sp.		10.9			10.0	12.5	(50)	3.3	11.1	22.2		5.9
Anisakis simplex												5.9
Raphidascaris acus		2.2	1.8				(50)		5.5	11.1		
Ascarophis arctica					10.0				5.5	11.1		
Echinorhynchus gadi	3.6	40.0	1.8		10.0		(50)	6.7	5.5	11.1		
Total prevalence	80	98	33	100	90	69	100	90	39	100	50	41
Sum of parasite species	4	9	8	2	6	6	7	6	9	8	2	7
Pomatoschistsus pictus												
Number of hosts	8	14	15	39	21	27	10	6	10	7	26	18
Trichodina spp.											3.8	22.2
Gyrodactylus spp.							10.0	83.3	10.0		15.4	11.1
Cryptocotyle concavum	25.0	78.6	100	15.4	33.3	48.1	70.0	83.3	80.0	57.1	84.6	100
Cryptocotyle lingua		35.7	93.3		4.8	14.8		33.3	10.0		7.7	
Apatemon gracilis			6.7					33.3				
Podocotyle atomon	100	85.7	26.7	100	100	55.5	100	100	10.0	100	100	61.1
Aphalloides timmi						3.7					3.8	
Zoogonoides viviparus			6.7									
Asymphylodora demeli	12.5	28.6	26.7		14.3	14.8	40.0					
Hemiurus communis			6.7									
Lecithaster confusus							10.0					
Lecithaster gibbosus						3.7						
Schistocephalus solidus						3.7					3.8	
Bothriocephalus sp.												5.5
Cestoda procercoids						3.7						
Hysterothylacium sp.		14.3	6.7			3.7			10.0		11.5	11.1
Contracaecum sp.			13.3		4.8				10.0		7.7	11.1
Anisakis simplex						3.7					3.8	
Raphidascaris acus					4.8						3.8	5.5

Table 1 (Contd.)

Year	1997			1998			1999			2000		
Month	June	July	September	June	July	September	May	July	September	June	July	September
Pomatoschistus minutus												
Ascarophis arctica			13.3					16.7			11.5	5.5
Echinorhynchus gadi		35.7		12.8	28.6	7.4		16.7	20.0		11.5	
Acanthocephalus anguillae						3.7						
Total prevalence	100	100	100	100	100	81	100	100	80	100	100	100
Sum of parasite species	3	6	10	3	7	12	5	7	7	2	13	10
Gobiusculus flavescens												
Number of hosts	12	21	31	20	14	17	23	17	26	15	15	16
Trichodina spp.								17.6	11.5	40.0	26.7	
Myxospora indet.				5.0								
Gyrodactylus spp.								94.1	26.9		93.3	
Cryptocotyle concavum	8.3	14.3		20.0	37.7	11.7	13.0	52.9	38.5	20.0	40.0	12.5
Cryptocotyle lingua								11.8			6.7	
Apatemon gracilis				5.0			4.3	17.6	3.8		6.7	
Podocotyle atomon	100	90.5		100	100	17.6	100	88.2		100	100	25.0
Asymphylodora demeli	8.3	23.8			7.1		4.3	5.9				
Hemiurus communis									3.8			
Lecithaster confusus					7.1	5.2						
Schistocephalus solidus					14.3				7.7			17.7
Ligula sp.											6.7	
Cestoda procercoids					14.3						6.7	
Hysterothylacium sp.		4.8										
Raphidascaris acus		19.0										
Echinorhynchus gadi		9.5										
Total prevalence	100	90	0	100	100	35	100	100	50.0	100	100	37
Sum of parasite species	3	8	0	4	7	3	5	7	7	3	8	4

Year	1997		1998	1999	2000	
Month	July	September	July	September	July	September
Gobius niger						
Number of hosts	6	26	4	18	4	13
Cryptocotyle concavum		15.4	25.0	22.5	25.0	61.5
Cryptocotyle lingua	33.3	7.7	75.0	22.5	50.0	61.5
Asymphylodora demeli					50.0	15.4
Microphallid metacercariae		15.3				
Hysterothylacium sp.	50.0	46.1	25.0	16.7	50.0	15.4
Contracaecum sp.		7.7		27.7		
Anisakis simplex						7.7
Raphidascaris acus	33.3	11.5		11.1	25.0	15.4
Ascarophis arctica					50.0	15.4
Echinorhynchus gadi	33.3	11.5	25.0	11.1	25.0	15.4
Pomphorhynchus laevis		15.4		27.7		7.7
Acanthocephalus anguillae				5.5		
Total prevalence	68	77	100	83	75	85
Sum of parasite species	4	8	4	8	7	9

Year Month	1997 May	1998 May	1999 June	2000 May
Pomatoschistus microps				
Number of hosts	63	38	34	27
Gyrodactylus sp.			17.6	51.8
Cryptocotyle concavum	98.4	100	100	100
Cryptocotyle lingua			14.7	11.1
Apatemon gracilis		47.4	70.6	70.3
Acanthostomum balthicum	11.1	2.6	29.2	3.7
Podocotyle atomon	47.6	39.5	44.1	11.1
Aphalloides timmi	58.7	39.5	100	100
Diplostomum spathaceum			2.9	11.1
Tylodelphis podicipina	1.6	2.6	2.9	7.4
Zoogonoides viviparus				3.7
Brachyphallus crenatus	3.2	2.6	2.9	
Asymphylodora demeli	15.9	5.3	35.3	7.4
Hemiurus communis	3.2			
Lecithaster gibbosus			5.9	
Magnibursatus caudofilomentosa			2.9	
Cardiocephalus longicollis	1.6		2.9	
Microphallid metacercariae			2.9	
Bothriocephalus sp.		2.6		
Proteocephalus percae	19.0	2.6	17.7	29.6
Hysterothylacium sp.			8.8	
Contracaecum sp.				3.7
Anisakis simplex	1.6	2.6		
Raphidascaris acus			5.9	7.4
Ascarophis arctica	1.6			18.5
Total prevalence	100	100	100	100
Sum of parasite species	12	11	18	15

Table 2 Seasonal coincidence of prevalence in two parasite species

Parasite	*Podocotyle atomon*		*Cryptocotyle concavum*	
Host	*F*	*P*	*F*	*P*
Pomatoschistus minutus	−15.0	> 0.05	0.5	> 0.05
Pomatoschistus pictus	3.7	0.05	6.4	< 0.05
Gobiusculus flavescens	4.3	< 0.05	0.7	> 0.05

in *Gobius niger*, *Neoechinorhynchus rutili* in *P. minutus* and glochidia in *Gobiusculus flavescens* from Dahmeshöved, as well as *Schistocephalus solidus*, *Cucullanus heterochrous* and *E. gadi* in *P. microps* from Salzhaff. These are regarded as rare species, including *E. gadi* in the Salzhaff (Zander et al. 1999). *N. rutili* and glochidia can only infect fish during casual stays in or near fresh or slightly brackish water.

Other parasite species which were not detected before were now found, especially in *P. pictus* from Dahmeshöved: *Trichodina* sp, *Gyrodactylus* sp., *Plagioporus alacer*, *Hemiurus communis* and *Ascarophis arctica*. Newly found in *Pomatoschistus minutus* were *Gyrodactylus* sp., *Tylodelphis podicipina* and *A. arctica* (also in *Gobius niger*), and in *Gobiusculus flavescens*: *Trichodina* sp. Still more numerous were the parasites newly detected in *P. microps*: *Hemiurus communis* and *Lecithaster gibbosus* were previously not known from the Salzhaff; *Magnibursatus caudofilomentosa, Brachyphallus crenatus* and *Tylodelphis podocipina* had already been found in sticklebacks (Zander et al. 1999), and *Plagioporus alacer* in *Gobius niger* (Jacobsen et al. 1971).

Some rare species are worth mentioning. *Brachyphallus crenatus* was previously found in the Salzhaff in several hyperbenthic fish, especially sticklebacks, but also in eels (Jacobsen et al. 1971; Zander et al. 1999; Reimer and Walter 2000), but until now they have not been found in gobies from Dahmeshöved. This parasite is probably more easily encountered by plankton feeders which predominantly ingest copepods, the second intermediate hosts. This was confirmed by the hyperbenthic *Gobiusculus flavescens* from Kiel Bight (Zander and Kesting 1996). *Pomatoschistus microps* may have ingested this parasite in the Salzhaff by chance, probably during its short planktonic larval phase. The distribution of *Derogenes varicus* is actually restricted to the Kiel Bight by its first intermediate host, *Natica* spp. which cannot survive at lower salinities. Therefore, the presence

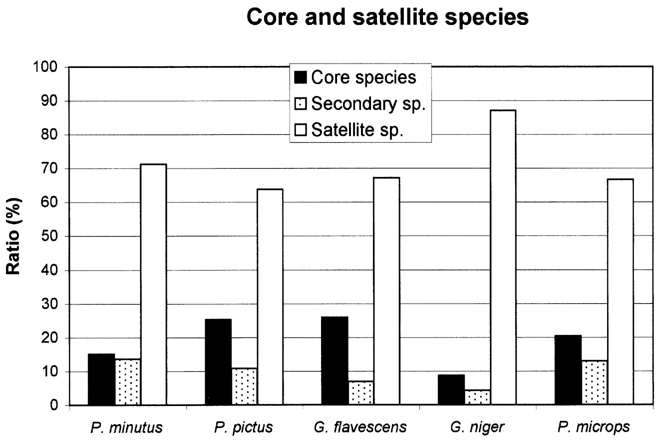

Fig. 2 Ratio of core, secondary and satellite species of five gobies from the south-western Baltic Sea

of this parasite must be due to casual drifts of infected copepods from Kiel to the Mecklenburg Bight (Zander and Reimer 2002). Another reason for changes in parasite communities in successive years is the low density of satellite species which may infect hosts mostly by chance.

Such changes are more obvious when the parasite communities from different seasons are considered. Disregarding *P. microps* from Salzhaff in which only spring samples attained high values of 11–18 parasite species, the number of parasite species was lower than that of a year, at most 13, 12 or 10 in *P. pictus*, and still lower in other hosts. This means that distinct parasites, especially cestodes and nematodes, but also some digeneans and acanthocephalans, appear only seasonally.

The seasonality of *Podocotyle atomon* in *Pomatoschistus minutus*, *Pomatoschistus pictus* and *G. flavescens*, core species in spring and summer but mostly satellite species in autumn, is in accordance with previous investigations from Dahmeshöved (Lübeck Bight), Blank Eck and western Fehmarn (Kiel Bight) (Zander et al. 1993, 2002; Zander and Kesting 1998). However, *Podocotyle atomon* peaked in the Salzhaff in summer and autumn in nine fish (Zander et al. 1999), but was never a core species in spring as was confirmed in this study. This results predominantly from the seasonal infection of the first intermediate host, *Littorina saxatilis*. Previously, *C. concavum* presented no clear seasonality in Lübeck Bight. Sticklebacks from western Fehmarn (Kiel Bight) were conspicuously infected

Table 3 Species identity (Sörensen index)

Species	1997	1998	1999	2000	May/June	July	September	*G. niger*	*G. flavescens*	*P. minutus*	*P. pictus*
Gobius niger	75.0[a]		66.7[b]	88.9[a]		63.9[b]	72.7[a]		44.4	60.0[b]	60.0[b]
Gobiusculus flavescens	52.4	51.8	63.3[b]	50.0	54.2	46.9	36.1	44.4		54.5	72.2[a]
Pomatoschistus minutus	[b]	58.3	56.4	51.5	50.0	57.5	42.7	60.0[b]	54.5		72.0[a]
Pomatoschistus pictus	50.0	52.4	57.6	55.5	54.2	55.0	45.2	60.6[b]	72.2[a]	72.0[a]	
Pomatoschistus microps					77.8[a]			50.0	46.1	71.4[a]	71.1[a]

[a]Values of greater conformity
[b]Moderate conformity

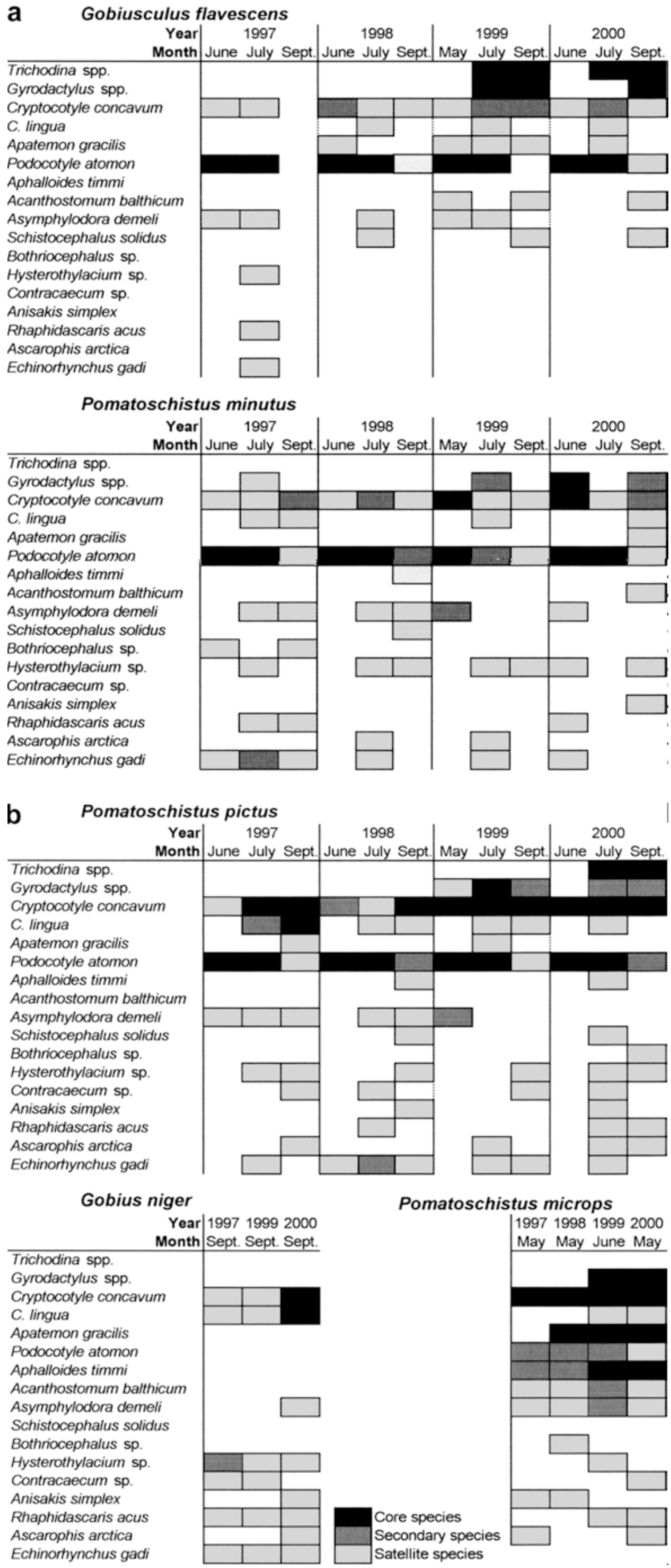

Fig. 3 Seasonal and yearly fluctuations of elected, relatively abundant parasites as core, secondary and satellite species in five goby hosts

in May and from August to October (Zander et al. 2002). *Pomatoschistus microps* from Salzhaff was severely infected over all seasons with a peak in autumn but the pipefish, *Syngnathus typhle*, was only host infected in spring (Zander 1998; Zander et al. 1999).

Podocotyle atomon and *C. concavum* are representatives of two groups which differ essentially in their route of infection of fish hosts: infection indirectly by transfer of prey organisms and directly by larvae penetrating actively into the host, respectively. In addition to *C. concavum*, the digeneans *Aphalloides timmi* and *Apatemon gracilis* also are active invaders which meet predominantly benthic fish due to their cercariae being released from benthic snails. *C. concavum* begins to infect young of the year *Pomatoschistus microps* immediately after these switch from free water to the bottom (Zander 1998; Zander et al. 1999). Most of the other digeneans were ingested with prey organisms. *Asymphylodora demeli* is even transferred in *Hediste (Nereis) diversicolor* to *Gobiusculus flavescens* in spring or summer when this hyperbenthic goby is dependent on benthic prey (Zander 1994).

Like *A. demeli*, other parasites were irregularly present as satellite species and very rare as secondary species. The nematodes *Hysterothylacium* sp., *Ascarophis arcticus* and *R. acus* as well as the acanthocephalian *E. gadi* were found in Dahmeshöved predominantly in summer. *Gobiusculus flavescens* was infected by three of these aschelminths only in summer 1997, which indicates that the host had foraged mostly on benthic prey organisms, although *Hysterothylacium* sp. may also have a planktonic life cycle (Køie 1993). The abundance values of *Hysterothylacium* sp. in *Gobius niger* might be underestimated because this nematode was previously found in greater quantities (Zander et al. 1993; Zander and Kesting 1996). This discrepancy may be caused by the present restricted investigation of this host. *E. gadi* was absent in *Pomatoschistus microps* from Salzhaff which confirms previous investigations of ten hosts from this locality where it was very rare (Zander et al. 1999). It was totally absent in western Fehmarn (Zander et al. 2002).

The life style patterns of the hosts investigated is mirrored by their parasite communities (Marcogliese 2002). Factors which build up parasite communities were compiled by Holmes (1990) into a model of filters and screens. Zoogeographical and environmental factors like salinity are responsible for the existence of the respective supra-community (local parasite fauna) (Zander and Reimer 2002). Food habits, behaviour, physiology (defence mechanisms) and the interactions of parasites are factors which form the component and infra-communities.

Feeding behaviour is the most important factor for the constitution of the parasite component community of each goby. *G. flavescens*, which lives hyperbenthically, only forages on the bottom at times of copepod paucity (Zander 1994). In consequence, it harbours many parasites which have planktonic intermediate hosts, especially copepods. The other gobies live on the bottom and only as larval and post-larval stages in the free water. In these hosts, the influence of parasites from the bottom prevails. The longer hyperbenthic stays of young *P. minutus* are just as conspicuous as the occasional movement of *P. pictus* into the free water for catching prey (Zander and Hagemann 1986, 1987; Zander 1994). This is why sand and painted goby harbour less hemiurid digeneans or cestodes than *G. flavescens*.

The duration of life of hosts as well as of parasites may be another element which determines the presence of parasites. *Gobius niger* is able to accumulate parasites like *Hysterothylacium* sp. (Zander et al. 1993). It is the only goby species which can live for more than 3 years, whereas the other species generally do not live longer than 1 year plus a reproductive period. Digeneans are rather short-lived parasites, therefore, *Podocotyle atomon* must have infected the hosts many times in order to attain a high concentration in spring and summer.

Defence mechanisms are assumed to exist in several host–parasite relationships. They become obvious in *Gobius niger* in which *Podocotyle atomon* was frequently absent (Zander et al. 1993, 1999). In other host–parasite relationships, the ratio of losses is also very high and causes low prevalences (Zander et al. 1994). *P. minutus* might have developed a higher threshold for the ability of parasites to settle (Zander et al. 1993). Coevolution between host and parasite is rarely found in the brackish Baltic and is known among the hosts studied here only from *Pomatoschistus microps* infected by the specialists *Aphalloides timmi* and *Apatemon gracilis* and by the generalist *C. concavum* which settles in a special microhabitat, the kidney (Zander and Reimer 2002).

In conclusion, the composition of the goby guild and component parasite community depends on the special ways of life of parasites as well as of hosts, and on the population density of intermediate hosts in which infection rates increase exponentially (Zander et al. 2002). In particular, mud snails (*Hydrobia* spp.) and benthic crustaceans (*Gammarus* and *Idothea* spp.) as herbivorous and detritivorous species profit from the eutrophication which prevails in the Baltic Sea (Zander 2002).

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